Forest Ecology and Management 400 (2017) 621–630

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

The influence of aquatic buffer zone vegetation on river macroinvertebrate communities

Cormac Mc Conigley [a,*], Heather Lally [a,b], Declan Little [c], Philip O'Dea [d], Mary Kelly-Quinn [a]

[a] School of Biology and Environmental Science, University College Dublin, Belfield, Dublin 4, Ireland
[b] Marine and Freshwater Research Centre, Galway-Mayo Institute of Technology, Dublin Road, Galway City, Ireland
[c] Woodlands of Ireland, Suite 2, Wicklow Enterprise Park, The Murrough, Wicklow, Ireland
[d] Coillte, Dublin Road, Newtownmountkennedy, Co Wicklow, Ireland

ARTICLE INFO

Article history:
Received 20 March 2017
Received in revised form 8 June 2017
Accepted 19 June 2017
Available online 30 June 2017

Keywords:
Riparian buffer zones
Conifer plantations
Forestry
Sitka spruce

ABSTRACT

Aquatic buffer zones (ABZs) are areas of the riparian zone managed to protect streams from the potential impacts of commercial conifer forests and associated forestry operations In Ireland. Previous research identified that the dominant vegetation communities in ABZs are wet grassland and scrub habitats and that the vegetation communities are broadly determined by the soil type (peaty or mineral). One of the primary management options available to forest managers is whether to plant native broadleaves in the ABZ or leave them to be naturally colonised. The present study sought to determine the degree to which the vegetation of ABZs influences the composition and structure of associated aquatic macroinvertebrate communities and how this might inform their future management in particular the decision of whether to afforest the ABZ with broadleaf trees. The macroinvertebrate communities from stream on peaty and mineral soils with ABZs dominated by four vegetation communities were sampled, streams bordered by grassland habitats, scrub habitats, no ABZ i.e. conifer trees planted to the streams edge and control streams with no conifer forests in the vicinity. The results of this study showed that the composition and structure of the macroinvertebrate community varied significantly between streams on peaty and mineral soils, but was largely unaffected by the ABZ type. The differences between communities across soil type can be attributed to the lower abundance and richness of Ephemeroptera and conversely the higher abundance and richness of Plecoptera in streams on peaty soils. The lack of a consistent effect of ABZ type on the macroinvertebrate community illustrates the more dominant effect of water chemistry driven by soil type particularly episodic acidity.

1. Introduction

The riparian zone is the area along a water body that marks the interface between aquatic and terrestrial ecosystems. In the case of rivers, it is generally considered to include the river banks and the area of land which is influenced by inundation during times of flooding (Gregory et al., 1991; Naiman and Décamps, 1997; Little et al., 2008). In headwater streams, the riparian zone may be small, in the order of a couple of meters (Hagan et al., 2006), while in large lowland rivers it extends to the maximum extent of the floodplain (Gregory et al., 1991). Changes to riparian zones vegetation arising from anthropogenic activities such as forestry, agriculture, urbanisation and mining, alter the chemical and physical conditions of rivers as well as the dynamics, structure and functioning of aquatic communities (Hynes, 1975; Gregory et al., 1991; Sweeney, 1993; Naiman and Décamps, 1997; Sovell et al., 2000; Allan, 2004; Dosskey et al., 2010). Therefore, in many countries, areas of the riparian zone, often termed riparian buffer zones (RBZs) or aquatic buffer zones (ABZs), are established and maintained for the protection of water quality from the impacts of adjacent land-use. Water quality protection is among the many benefits from riparian vegetation that are becoming increasingly important in the context of payments for ecosystem services.

In Ireland, ABZs were made a mandatory feature in all forests planted or replanted since 1991 (Forest Service, 2000). The ABZs range from 10 to 25 m wide, depending on local soil conditions and slope. Their primary function is to minimise diffuse pollution inputs from forestry operations, in particular, sediment and nutrients, which can arise during potentially high impact forest operations, such as road construction, harvesting and ground preparation for replanting (Leeks and Roberts, 1987; Kreutzweiser et al., 2005; Finnegan et al., 2012; Clarke et al., 2015).

* Corresponding author.
E-mail address: cormacmcconigley@gmail.com (C. Mc Conigley).

http://dx.doi.org/10.1016/j.foreco.2017.06.043
0378-1127/

Much of the research to date on riparian buffer zones has focussed on their capacity to attenuate nutrient and sediment pollution (Vought et al., 1994; Lee et al., 2003; Nieminen et al., 2005; Finnegan et al., 2012), with less focus on the links between the vegetation and the aquatic communities. Planting native broadleaved tree species and management might optimize beneficial interactions. The management strategy for ABZs in Ireland to date has been to leave them undisturbed and allow vegetation to naturally colonise from local seed sources. Thus, the vegetation composition and structure of ABZs is comparable to that of natural riparian communities (Mc Conigley et al., 2015). Future management options will need to consider the connectivity between riparian zones and adjacent water bodies and to question whether active management, in terms of native tree planting or maintenance of grassy swards and herbaceous vegetation has measurable effects on aquatic communities.

The presence of deciduous trees and shrubs in the riparian zone can influence aquatic macroinvertebrate communities though altering the availability of food sources. Trees for example can reduce the amount of light reaching the stream surface through shading, depending on the extent of overhang and the width of the aquatic zone. This can limit primary production (Vannote et al., 1980; Sweeney, 1993; Ghermandi et al., 2009) with consequences for secondary production and instream trophic structures (Kiffney et al., 2003; Lecerf et al., 2012) and thermal regimes, in particular, reducing maximum water temperatures (Broadmeadow et al., 2011; Ryan et al., 2013). Deciduous trees also provide large quantities of organic matter in the form of leaves and woody debris which contribute to the streams energy budget, forming the primary energy source in forested headwater streams (Delong and Brusven, 1994; Wallace et al., 1997) as well as influencing *in situ* macroinvertebrate communities. Inputs of course particulate organic matter, such as leaves have been shown to increase the abundance of shredder species (Drake, 1984; Richardson, 1991; Wallace et al., 1997) and yield increased metabolic activity, arising from the high-energy input (Sweeney et al., 2004; Bott et al., 2006). Leaves also make up one of the main food sources for many detritivores invertebrates (Sweeney, 1993; Heino, 2005) and the exclusion of allochthonous leaf material has been found to reduce abundances and biomass of macroinvertebrates in general (Wallace et al., 1999). Furthermore, woody debris aids in retaining other organic matter within stream reaches where it can be utilised by micro- and macro organisms (Speaker et al., 1984; Wiley et al., 1990; Gregory et al., 1991). The occurrence of feeding groups such as shredders are important in processing allochthonous detritus particularly in a forested catchment. This can potentially increase the food resource available and influence higher tropic levels.

Grass-dominated bordered streams, on the other hand, receive more direct sunlight allowing for higher water temperatures during the summer, and greater primary production when compared with forested streams (Sweeney, 1993; Broadmeadow et al., 2011; Ryan et al., 2013). However, these streams would be expected to receive less allochthonous organic matter than those with a wooded riparian zone (Wiley et al., 1990), which may affect overall macroinvertebrate productivity. It could be expected therefore that streams with grass dominated riparian zones would have a macroinvertebrate community dominated by taxa that utilise autochthonous food sources such as grazers.

The present study sought to determine the degree to which the vegetation of ABZs influences the composition and structure of associated aquatic macroinvertebrate communities and how this might inform their future management. Soil type is an import factor influencing both riparian vegetation (Mc Conigley et al., 2015) and stream chemistry (Bluth and Kump, 1994), and therefore was considered in the study design.

It was hypothesised that:

Macroinvertebrate communities in streams with an ABZ would more closely resemble communities in control streams (no conifer forestry in the vicinity) than the community in streams with no ABZ.
Macroinvertebrate communities in streams with scrub ABZs would contain a larger proportion of shredders and associated filter feeders due to the availability of leaf litter, while grazers would predominate in ABZ types without trees in the riparian zone because increased light would shift food availability towards more benthic algae and less allochthonous inputs from the surrounding forest.

2. Materials and method

2.1. Site Selection

Sites were selected using aerial photography and ordnance survey maps (OSI Discovery map series 1:50,000 scale) to identify river sections of suitable length within conifer forest. Two soil types were chosen for comparison following on from the findings of Mc Conigley et al. (2015), that the primary separation in plant communities was between peaty (i.e. organic) and mineral soils. The most commonly encountered habitats in ABZs were wet grassland and scrub habitats (Mc Conigley et al., 2015). ABZs dominated by these habitats were compared with control sites which had no conifers present and streams where conifers were planted to the streams edge (i.e. no ABZ). This resulted in four ABZ types, summarised below, across two soil types, combined to give eight categories. Excluding the control sites, all had conifer forests on both sides of the stream. In almost all cases, the forests were dominated by *Picea sitchensis* Bongard (Sitka spruce) with occasional *Pinus contorta* Douglas ex Louden (Lodgepole pine).

- **Streams bordered by grassy ABZs:** grassland habitats dominated the ABZ, in most cases wet grasslands dominated by *Molinia caerulea* (L.) Moench (purple moor-grass).
- **Streams bordered by scrub ABZs:** scrub habitats dominated the ABZ with species such as *Fraxinus excelsior* (L.), *Salix* spp., *Betula* spp., *Alnus glutinosa* (L.) and *Ulex europaeus* (L.) most common.
- **No ABZ:** streams with conifer trees planted to the streams edge. In all cases *P. sitchensis* was the dominant tree species.
- **Control streams:** streams with no conifer forests in the catchment, on peaty soils the streams were in open heathland with *Molinia caerulea* and *Calluna vulgaris* (L.) Hull, while on mineral soils, native woodland occurred with typical species including *Quercus petraea* (Mattuschka) Liebl, *F. excelsior* and *Betula* spp.

Four replicate streams within each combination of soil type and ABZ type (Table 1, 32 streams in total) were sampled over a four week period in spring (April–May) 2012 and again over a three week period in autumn (October) 2012. There is considerable variation in rainfall across Ireland, the west coast receives approximately 2000 mm in 250 days of rain annually while on the east coast 700 mm of rain falls in 190 days. In order to take account of the variations in climate particularly rainfall across the country half of the streams in each category were located in the west of the country and half in the east, with the exception of scrub buffered streams on peat, of which three of the sites were in the west (Fig. 1). Site location and characteristics are given in Table 1.